THE STRUCTURE, EVOLUTION, AND DYNAMICS OF COASTALLY TRAPPED PHENOMENA OF WESTERN NORTH AMERICA

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LONG-TERM GOALS

The overall goal of the proposed project is to determine the structure, evolution, and dynamics of topographically trapped phenomena of the coastal zone of western North America, both for the warm and cold seasons. Such coastal circulations dominate the weather of the region, as well as many other coastal zones around the world. Because of improvements in mesoscale numerical models, significant improvements in operational observations, and the availability of data from recent coastal field experiments, there is substantial potential for rapid enhancement in our knowledge of coastal disturbances. This project makes use of high-resolution numerical modeling and aircraft observations to define the detailed coastal evolution for a number of coastally trapped features and evaluates the potential of numerical modeling as a research and forecasting tool for orographic coastal regions.

OBJECTIVES

The major scientific objectives of the project include the following:

* Determination of the three-dimensional structural evolution and dynamics of coastally-propagating disturbances along the West Coast during the warm season.
* Determination of the structural evolution and dynamics of mesoscale coastal pressure ridges and jets.
* Determination of how the structures and dynamical balances of synoptic systems such as troughs and fronts change as they approach and cross mountainous coastlines.
* Determination of the synoptic evolution accompanying coastally trapped wind reversals.
* Determination of the origin and three-dimensional structures of mesoscale troughing in the coastal zone and the evaluation of the contribution of such troughing to the production of coastal southerlies along the west coast of North America.
* Evaluation of the ability of current high-resolution numerical models to realistically simulate mesoscale coastal flows and to assimilate coastal observations.

APPROACH

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This project has used two major approaches to describe the structures and dynamics of topographically trapped coastal features:

1. High-resolution numerical modeling using the Penn. State/NCAR model (MM5). Going to horizontal resolution as high as 1 km, a number of summer and wintertime coastal features have been simulated. The data from the simulations provide a rich data set for exploring the evolution and structures of coastal phenomena. The model has also been used for several sensitivity experiments in which various physical processes are modified or removed.

2. Analysis of observational data using aircraft and other platforms. The PI has been involved in the COAST field experiment in which the radars and flight level instrumentation of the NOAA P3 aircraft has been used to provide a very detailed picture of the flow and precipitation fields around a number of orographic barriers from California to British Columbia. Analysis of these data sets provides an unequaled detailed view of coastal atmospheric structures.

WORK COMPLETED

During the past year the PI has worked on a wide variety of research efforts in support of the project's goals:

1. The PI in cooperation with Simon-Low Nam and Chris Davis of NCAR have completed two Catalina Eddy events using the Penn. State/NCAR mesoscale model, version 5 (MM5). We have also completed a simulation of the 10 June 1994 coastal surge that moved northward along the central California Coast. Two papers are now being prepared.

2. The PI and Jim Steenburgh of the University of Utah, have produced highly realistic simulations of a summertime coastal surge that moved up the Northwest coast on 19-21 July 1994 using the MM5. Several simulations, some with 4 km resolution, have produced the most detailed description of a coastal surge to date. A paper based on this work has been submitted to *Monthly Weather Review*.

3. The PI and his student, Brian Colle, have used both NOAA P3 aircraft data and high resolution MM5 simulations to describe the interaction of wintertime front with the Olympic Mountains of Washington State during COAST IOP5. A paper describing this work has been submitted to *Monthly Weather Review*.

4. The PI and graduate student Brian Colle, have examined the development of downslope windstorms on coastal orography when low centers approach the coast while cold air is entrenched inland. Two papers based on this work have been accepted for publication.

5. The PI has had considerable interaction with operational Navy personnel in the Puget Sound region and is now running the MM5 operationally at 12 and 4 km resolution for the coastal zone of the Northwest.

6. The PI and Fang-Ching Chien, a graduate student, have completed an observational and modeling study of the interaction of a warm season front with the orography of the Pacific Northwest. This case, involving a coastally trapped alongshore surge, the onshore push of marine air, and the development of a convergence zone in the lee of the Olympics Mountains, was well simulated by the

MM5. Using the model output and available observational data, the detailed structural evolution of these features has been determined and the changing dynamics of the frontal trough during landfall has been determined.

7. The PI and colleagues have completed work on cold air gaps flows in coastal terrain during a landfalling cyclone.

RESULTS

Some important results have come out of the above work so far. First, we have demonstrated that high-resolution mesoscale models can realistically simulate mesoscale features in the coastal zone produced by the interaction of the synoptic scale flow and orography. Using the model data sets we have described the detailed structural and dynamical evolutions of a variety of coastal phenomena, ranging from Catalina Eddies and coastal surges, to the interaction of fronts with coastal orography. Second, using the data sets produced by the COAST field experiment we have provided a very detailed look at the mesoscale structures that occur as synoptic scale systems approach and cross coastal mountains during the winter. The aircraft-based observations have provided probably the best coastal data sets in existence for studying frontal/coastal orography interactions. The COAST data sets also allow a detailed verification of the model output in a way that is not possible with conventional observations.

IMPACT/APPLICATIONS

This work substantially clarifies the structural evolution and dynamics of a number of orographically trapped features along the west coast of North America and demonstrates the potential of high resolution numerical modeling for warm and cold season events.

TRANSITIONS

Several of the mesoscale modeling approaches developed at the University of Washington have been transferred to other groups. Furthermore, the work on the synoptic environment of coastally trapped disturbances has greatly influenced other groups working on this problem.

RELATED PROJECTS

A substantial amount of the work on coastally trapped summertime disturbances has been done in concert with an ONR-sponsored effort at the MMM Division at the National Center for Atmospheric Research.

REFERENCES

Publications sponsored in total or part by this grant during the last year include:

Colle, B. A. and C. F. Mass, 1997: An observational and numerical study of a cold front interacting with the Olympic Mountains during Coast IOP 5. Submitted to *Mon. Wea. Rev.*

Bond, N. A., C. F. Mass, B. F. Smull, R. A. Houze, M.-J. Yang, B. A. Colle, S. A Braun, M. A. Shapiro, B. C. Colman, P. J. Neiman, J. E. Oveland, W. D. Neff, and J. D. Doyle, 1997: The coastal observation and simulation with topography (COAST) experiment.*Bull. Amer. Meteor. Soc.*, **78**, 1941-1955

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Chien, F. C., C. F. Mass, and Y.-H. Kuo, 1997: A numerical study of the interaction between a warm-season frontal system and the coastal mountains of the western U.S., Part I: prefrontal pressure ridge, onshore push, and alongshore southerlies. *Mon. Wea. Rev.*, **125**, 1705-1729

Chien, F. C. and C. F. Mass, 1997: A numerical study of the interaction between a warm-season frontal system and the coastal mountains of the western U.S., Part II: Evolution of a Puget Sound Convergence Zone. *Mon. Wea. Rev*., **125**, 1730-1752

The real-time west coast high resolution mesoscale modeling can be viewed at the following web site: http://www.atmos.washington.edu/data/mm5.cgi